

CLAIMS

What is claimed is:

1. A method for reducing the contact resistance of metal silicide contacts comprising the steps of:
 - (a) forming a metal germanium alloy layer over a silicon-containing substrate, wherein said metal is Co, Ti, Ni or mixtures thereof;
 - (b) annealing said metal germanium alloy layer at a temperature sufficient to convert at least a portion of said metal germanium alloy layer into a metal silicide layer that is substantially non-etchable compared to the unreacted metal germanium alloy layer, while forming a Si-Ge interlayer between said silicon-containing substrate and said substantially non-etchable metal silicide layer;
 - (c) removing any remaining metal germanium alloy layer, with the proviso that when Ti or Co are employed a second annealing step follows step (c) that is capable of converting the substantially non-etchable Ti or Co silicide phase into Co disilicide or C54 phase of $TiSi_2$.
2. The method of Claim 1 further comprising pre-annealing the metal germanium alloy layer prior

3 to step (b) at a temperature sufficient to form
4 a metal rich germanium silicide layer.

1 3. The method of Claim 1 wherein said metal
2 germanium alloy layer is formed by a deposition
3 process selected from the group consisting of -
4 chemical vapor deposition (CVD), plasma-
5 assisted CVD, sputtering and evaporation, or
6 said metal germanium alloy layer is formed by
7 first depositing said metal to form a metal
8 layer and then doping said metal layer with
9 germanium.

1 4. The method of Claim 1 further comprising
2 forming an optional barrier layer over said
3 metal germanium alloy layer prior to step (b),
4 wherein said optional barrier layer is removed
5 by step (c).

1 5. The method of Claim 1 wherein said metal
2 germanium alloy layer further includes at least
3 one additive selected from the group consisting
4 of C, Al, Si, Sc, Ti, V, Cr, Mn, Fe, Co, Ni,
5 Cu, Y, Zr, Nb, Mo, Ru, Rh, Pd, In, Sn, La, Hf,
6 Ta, W, Re, Ir, Pt, Ce, Pr, Nd, Sm, Eu, Gd, Tb,
7 Dy, Ho, Er, Tm, Yb, Lu and mixtures thereof.

1 6. The method of Claim 5 wherein said additive is
2 C, Al, Si, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu,
3 Y, Zr, Nb, Mo, Ru, Rh, Pd, In, Sn, La, Hf, Ta,
4 W, Re, Ir, Pt or mixtures thereof

- 1 7. The method of Claim 6 wherein said additive is
2 Si, Ti, V, Cr, Ni, Nb, Rh, Ta, Re, Ir or
3 mixtures thereof.
- 1 8. The method of Claim 1 wherein said metal
2 germanium alloy layer contains from about 0.01-
3 to about 50 atomic % Ge.
- 1 9. The method of Claim 8 wherein said metal
2 germanium alloy layer contains from about 0.1
3 to about 20 atomic % Ge.
- 1 10. The method of Claim 1 wherein said metal of
2 said metal germanium alloy layer is Co.
- 1 11. The method of Claim 4 wherein said optional
2 oxygen barrier layer is composed of TiN.
- 1 12. The method of Claim 1 wherein said silicon-
2 containing substrate comprises a single crystal
3 Si, polycrystalline Si, SiGe, amorphous Si, or
4 a silicon-on-insulator (SOI).
- 1 13. The method of Claim 2 wherein said pre-
2 annealing step is carried out using rapid
3 thermal annealing (RTA).
- 1 14. The method of Claim 13 wherein said RTA is
2 carried out at a temperature of from about 350°
3 to about 450°C for a time period of about 300
4 seconds or less

- 1 15. The method of Claim 1 wherein said annealing
2 step (b) is carried out by RTA.
- 1 16. The method of Claim 15 wherein said RTA is
2 carried out at a temperature of from about 400°
3 to about 700°C for a time period of about 300 ~
4 seconds or less.
- 1 17. The method of Claim 1 wherein said remaining
2 metal germanium alloy layer is removed
3 utilizing a wet etch step that includes the use
4 of an etchant that is selective for removing
5 said layer.
- 1 18. The method of Claim 1 wherein said second
2 annealing step is carried out by RTA.
- 1 19. The method of Claim 18 wherein said RTA is
2 carried out at a temperature of from about 700°
3 to about 900°C for a time period of about 300
4 seconds or less.
- 1 20. The method of Claim 1 wherein said metal is Ni
2 and Ni monosilicide is formed after step (b).
- 1 21. The method of Claim 1 wherein said metal is Co
2 and Co monosilicide is formed after step (b).
- 1 22. The method of Claim 1 wherein said metal is Ti
2 and C49 phase of TiSi_2 is formed after step
3 (b).

1 23. An electrical contact to a region of a silicon-
2 containing substrate comprising:

3 a substrate having an exposed region of a
4 silicon-containing semiconductor material; and

5 a first layer of metal disilicide, wherein said
6 metal of said disilicide is selected from the
7 group consisting of Ti, Co and mixtures
8 thereof, and said substrate and said first
9 layer are separated by a Si-Ge interlayer.

1 24. An electrical contact to a region of a silicon-
2 containing substrate comprising:

3 a substrate having an exposed region of a
4 silicon-containing semiconductor material; and

5 a first layer of Ni monosilicide, wherein said
6 substrate and said first layer are separated by
7 a Si-Ge interlayer.
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